FLEX

Facility for Low Energy eXperiments in Buildings

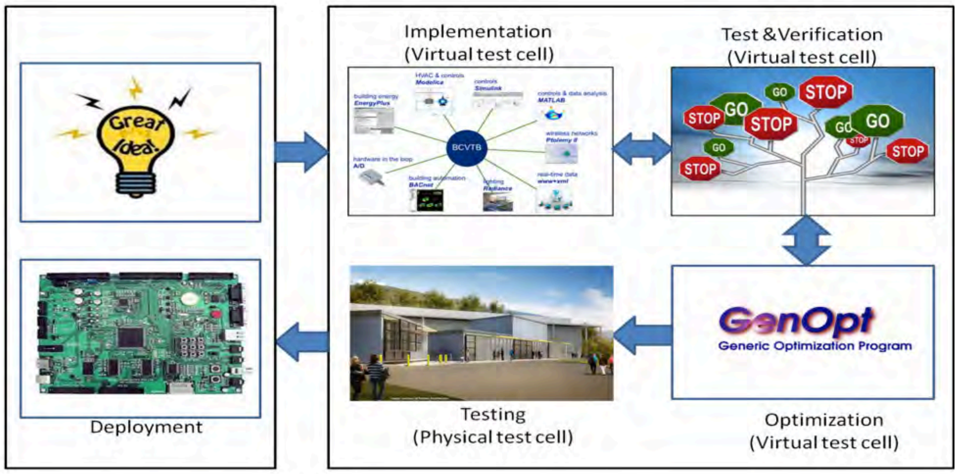
# FLEX for Model Based Controls – Use Case

## Development of innovative controls algorithm for complex façade systems

### The Challenge

Although there exist a large number of complex façade systems for reduction of solar heat gains in buildings, there is still a lack of innovative control algorithms capable of delivering high-quality, low-energy solutions.

**FLEX** offers a unique opportunity for industry and researchers to collaboratively solve 'stretch' problems of this type by providing them a platform that can be used to develop, test and optimize innovative controls algorithms for complex façade systems.




**A computer-based virtual testbed is part of the available FLEX resources. This virtual testbed incorporates Modelica models as software for implementation, testing, verification and optimization of innovative controls algorithms for complex façade systems.**

### Starting Point

A controls company approaches LBNL with an idea to evaluate and optimize an innovative control algorithm for active façades before commercialization and deployment.

### Solution Pathway

The controls engineer verifies the correct operation of the control algorithm, offline, in a computer-model of a test cell. Since validated Modelica models for each test cell are available, one only needs to implement the controls algorithm for performance verification. The model is then used to further improve the algorithm, running annual simulations in a minute's time, thus allowing for multiple design iterations. Once the algorithm performs satisfactorily in simulation, the controls engineer automatically generates C code from the Modelica model to implement on actual control hardware. LBNL developed software is then used to link the control hardware to the computer model of the desired test cell. This real-time implementation of physical hardware may have communication delays and signal quantification errors that were not part of the simulation model. Once the test implementation is successful, a three-months field performance test is conducted, in which the algorithm controls the façade systems of the physical test cell. The experiment is analyzed in real-time and compared to simulated reference data to identify and correct possible experimentation. Using physical measurements, the model is recalibrated and used to assess economic and energy benefits across different climate zones. Finally, the algorithm is commercialized, and results from the measurements are used to illustrate and explain the performance of the algorithm to customers.

| Testbed Capabilities | Performance Parameters and Benefits |
|---|---|
| Buildings simulation models | EnergyPlus/Modelica/Radiance tools to model control strategies, lighting/HVAC, and whole "testbed" energy use |
| Hardware-in-the-loop simulation tools | Virtual test-bed to link different simulation tools during run-time and link simulation tools with real hardware |
| HVAC control and energy use | Zonal load measurement |
| Robust data acquisition system to accommodate additional instrumentation | Flexibility to integrate experiment-specific measurement hardware with existing testbed instrumentation |

## Immediate Outcomes

- Developed and optimized control algorithms for active façades that achieve energy savings in buildings.
- Holistic archival set of high-quality field-measured data for use in manufacturer documentation and publications.
- Test-bed results and information to adjust system control logic, or component performance, if energy or comfort performance is lower than target.

## Extended Validation & Deployment Opportunities

- Use of field-measured data and virtual testing to simulate and extrapolate findings to diverse climates, room geometries, envelope types, HVAC systems, and whole-building performance.
- Partner with LBNL researchers with subject matter expertise.
- Use the virtual testbed to conduct optimization in virtual environment prior to time-consuming full-scale testing.
- Use the virtual testbed for hardware-in-the-loop simulation for verification and real-time monitoring.

## References and Further Reading

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